GSI SD-Seminar

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Data Aquisition for the UNILAC **B**eam **C**urrent **T**ransformers

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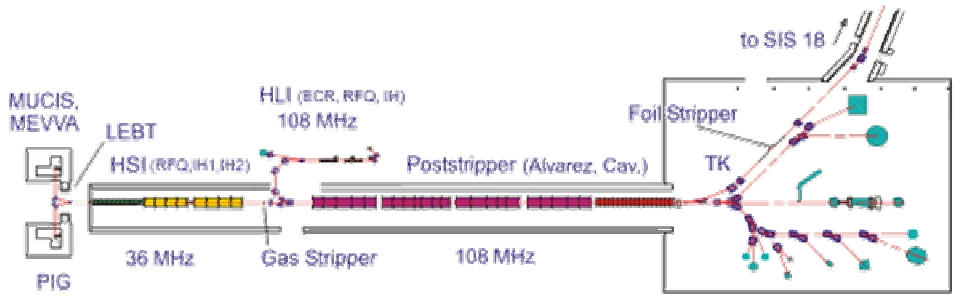
Overview

- UNILAC operation
- Beam Current Transformers & Specifications
- BCT System Layout
  - BCT mechanics & electronics
  - Distributed system structure
  - DAQ stations
- DAQ, Readout and Logging via the GSI control system
- Beam pulse time structure display by local PC
- "**Ma**kro **P**ulse **S**elektor"

UNILAC operation mode

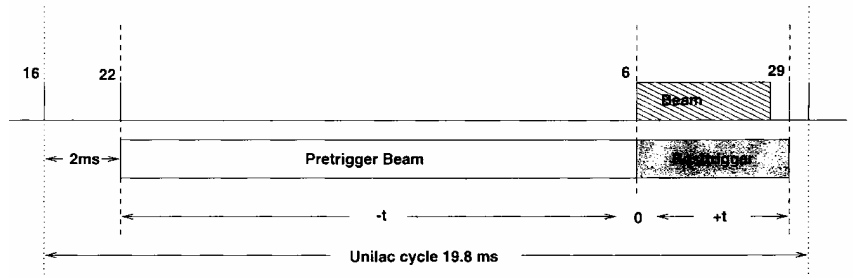
Each UNILAC pulse has his own parameter setup (out of 14 possibilities) **-> Virtual Accelerator!**

- the UNILAC is a 50 Hz machine, operates line-synchroneous
- macro-pulse length: 10 µs to 8.2 ms
- beam intensities: from the µA region to ~ 100 mA in LEBT and source area
- 3 ion sources can deliver beam at a time
- 3 local experiments and the SIS can be provided with beam pulses
- UNILAC can switch specific energy and ion species pulse-by-pulse, thus operating in a complex pulse pattern
- BCT settings must be switched as well !
- data are read continuosly from all DAQ channels, displayed on demand

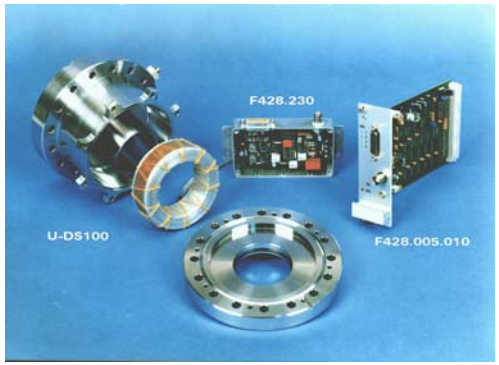


- 42 BCTs in LEBT, HSI, HLI, Poststripper and TK sections
- each section has dedicated timing
- 8 timing zones -> 8 BCT crates and VME controllers

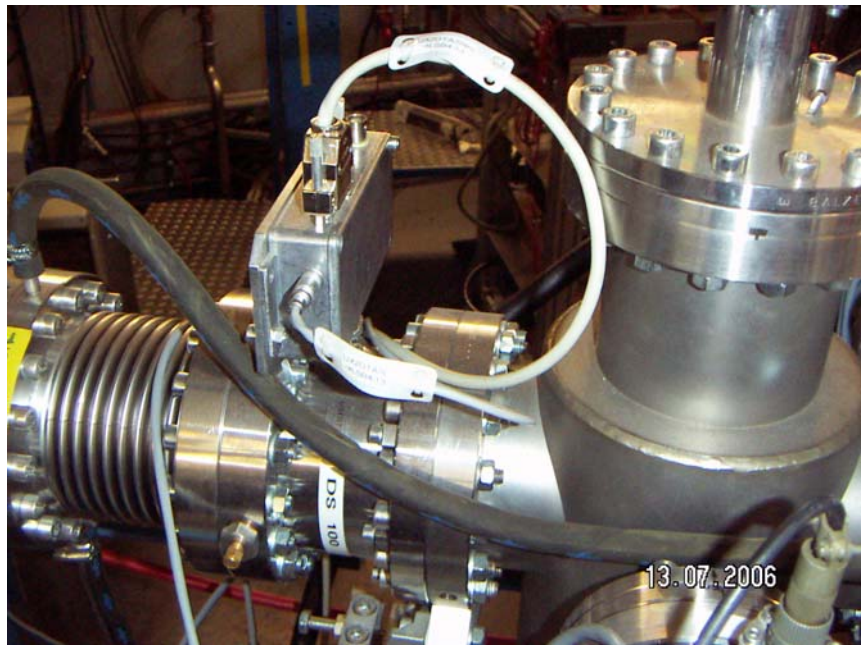
UNILAC timing diagram:



BCT, type U-DS100, mounted somewhere in the UNILAC experimental area ...

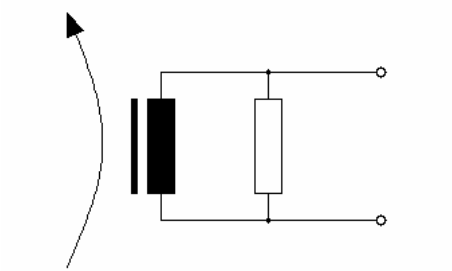


- Aperture: 48 mm
- Length: 100mm
- Flanges: DN100CF
- Ferritic stainless steel vacuum housing acts as magnetic screen
- O-RIng is vacuum seal and mirror current barrier
- Toroid with differential cross-winding reduces hum
- Head amplifier: switchable gain, mounted close to the toroid / beam pipe
- Digital integrator measures pulse charge and gate length



- locally mounted front end
- remote control/DAQ module placed outside tunnel
- fixed-range output for ion transmission survey & control
- approx. 40 devices installed along the accelerator and beam transfer lines

Basic circuits of Pulse (AC) Current Transformers

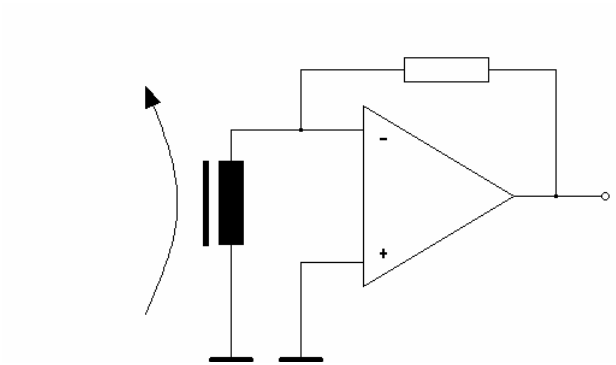


N_p(1!) N_{sec} R

passive BCT:

$V_R = (I_b * R / N_{sec}) * e^{-t/\tau}$

time constant $\tau \sim L / R$



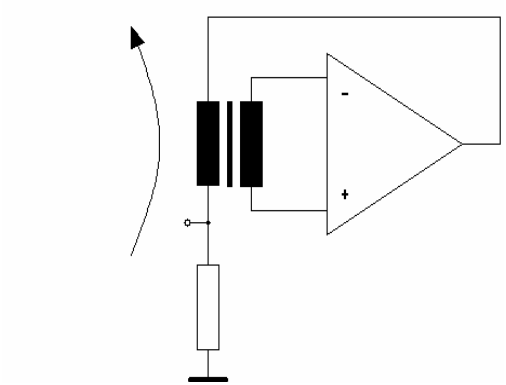
N_p (1!) N_{sec} R A

active BCT: I/V-converter

$V_o \sim (I_b * R / N_{comp}) * e^{-t/\tau}$

time constant $\tau \sim L / (R / A + R_N)$!

Improved circuits of Pulse (AC) Current Transformers

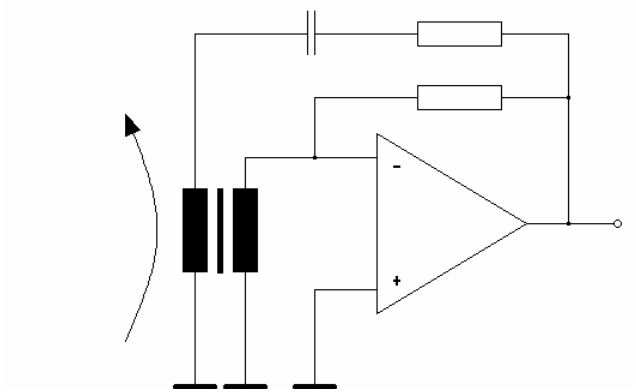


$N_p(1!)$ R_{fb} N_{comp} N_{sens} A

active BCT: L/R-integrator (Hereward / CERN)

$V_R \sim (I_b * R_{fb} / N_{comp}) * e^{-t/\tau}$

time constant $\tau \sim M / (R_{fb} * A)$!



Np(1!) N_{comp} N_{sens} C R_{comp} R_{fb} A

active BCT: 2nd order feedback (Schneider / GSI)

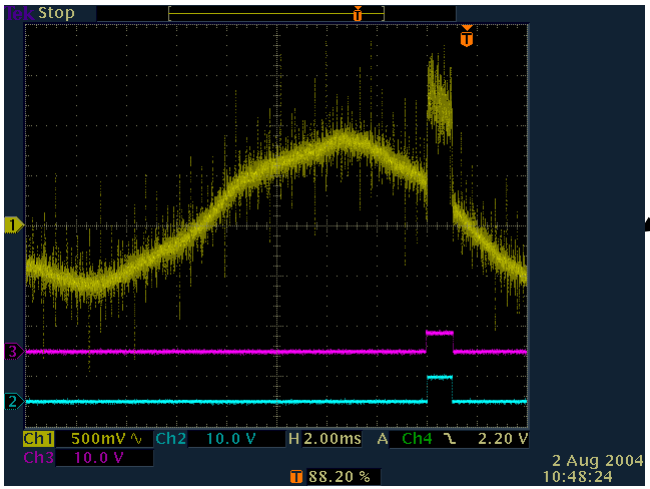
$V_o \sim (I_b * R_{fb} / N_{comp}) * e^{-t/\tau}$

time constant $\tau \sim M / (R_{fb} * A)$!

GSI Linac-BCT: active current transformer

• **CT principle:**	I/U-converter, additional feedback (N. Schneider/GSI)
• **Magnetic ribbon in toroid:**	Supermalloy (or Vitrovac® 6025F), t = 25 µm
•**Winding scheme, typ.:**	N_{Isense}=2 x 10, N_{fb}=1, N_{test} =1
• **Main signal output:**	current source, for burden resistance 50 Ω
• **Interlock output:**	current source, fixed gain
• **Gain Ranges:**	5, 10 .. 100 µA, 1 .. 10 .. 100mA full scale
• **Output rise time:**	~1 µs small signal, < 5 µs full step
• **Pulse "droop" error:**	< 0.1% / msec
• **Max. permissible pulse length:**	8191 µs
• **Amplification error:**	< 0,2 % (for I <20 mA)
• **Linearity error:**	~ 0,1 % (for I <20 mA)
• **Resolution, Nyquist-noise dominated:**	~ 500 nArms @ 2 ms pulse length, S/N=1
• **Signal transmission, toroid to front end:**	differential, shielded twisted pair lines, 0.25 m
• **Signal transmission, front end to DAQ module:**	shielded differential

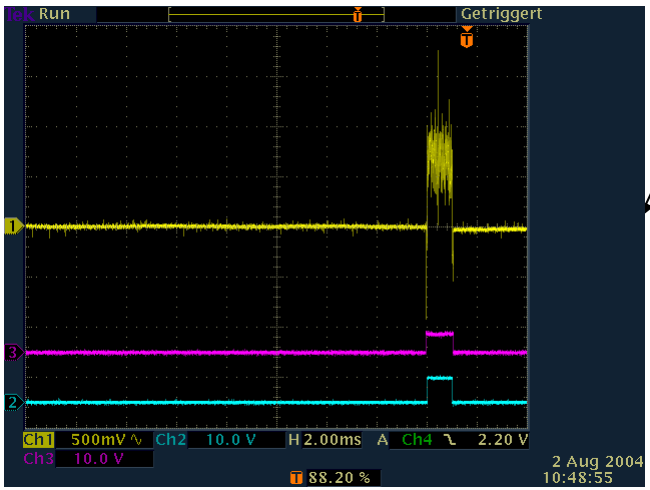
BCT signal at beam currents with lower intensity

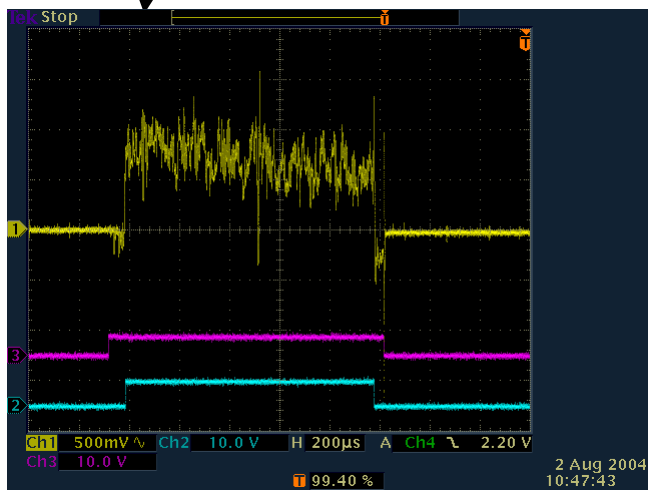


beam current signal (macro pulse) sitting on typicall hum perturbation

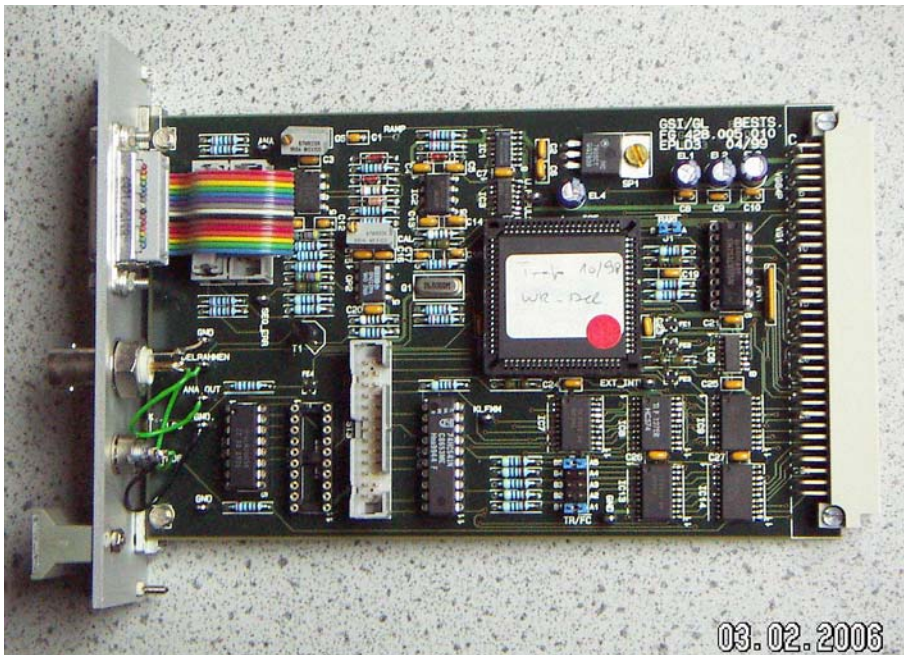
BCT signal **clamped** to zero outside beam pulse

a closer view; mean pulse current approx. 17 µA; **gate pulse** defines integration time



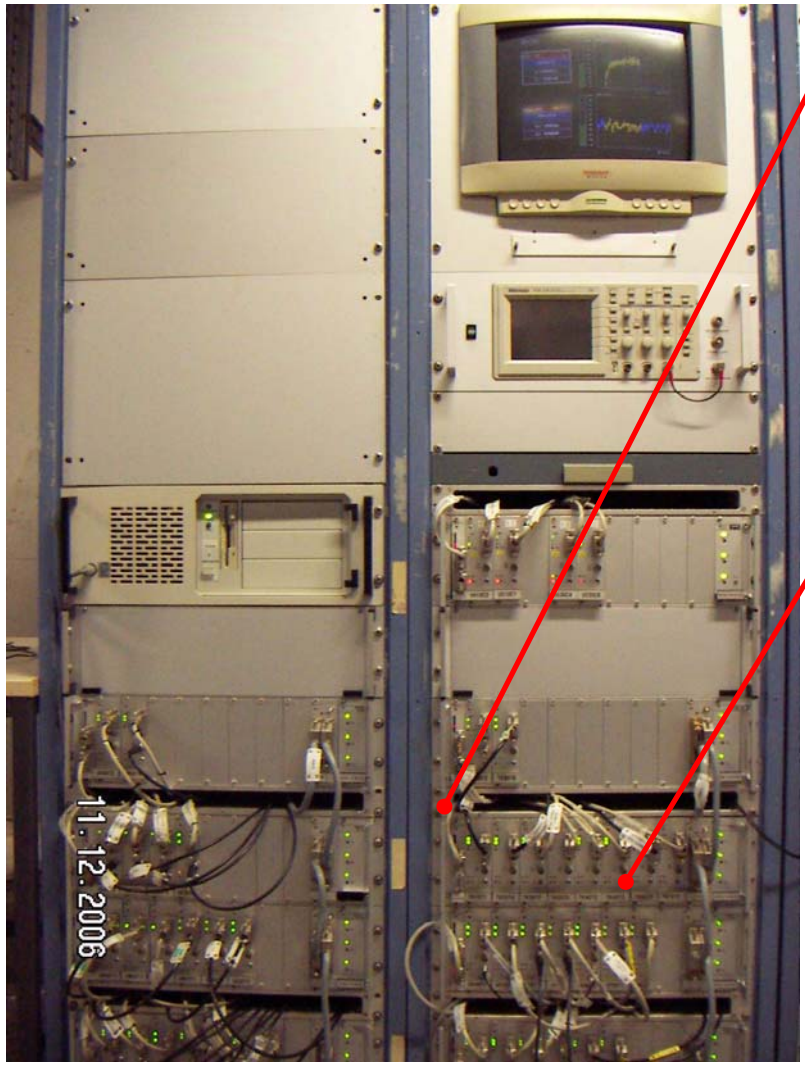


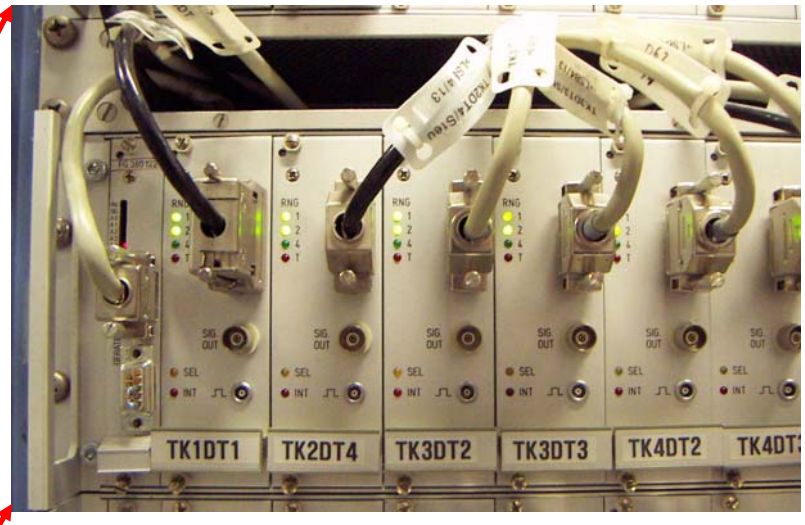
BCT DAQ electronics, associated with GSI control system hardware



1. differential line receiver, fixed gain
2. V/f-Converter, fmax = 8(12) MHz
3. programmable gate pulse delay
4. gate pulse input selector
5. 2 gated 16-bit-counters
6. status register (OVLD, SEQ_ERR. etc.)
7. I/O-driver for head amplifier
8. sequential logic and bus transfer ->
9. reprogrammable ALTERA 7000 CPLD for digital core
10. also configurable for Faraday-Cups

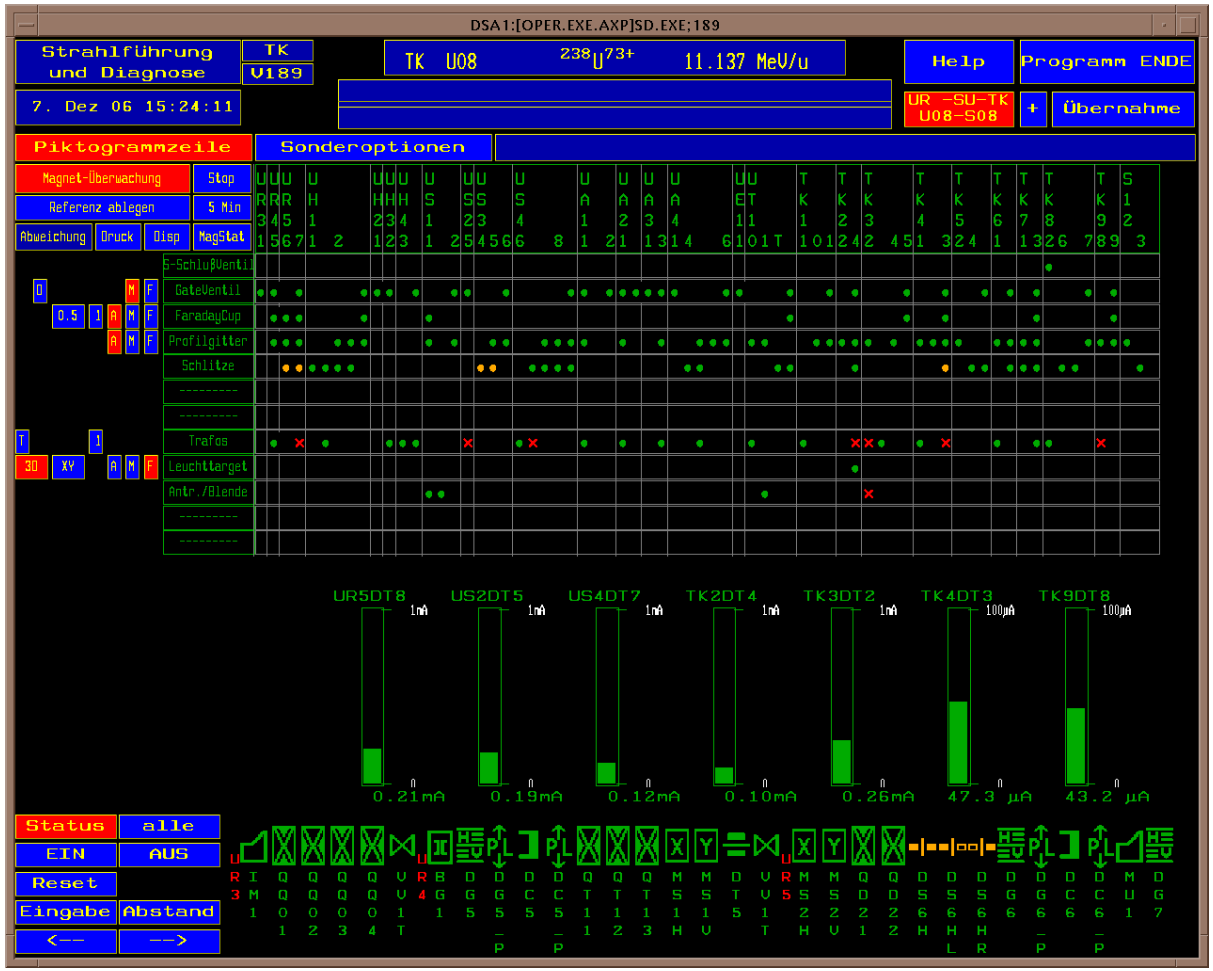
BCT DAQ electronics station in LSB4, outside tunnel





- BCT DAQ channel: differential line receiver - U/f-converter – pulse counter chain
- up to 8 channels per crate, MIL-1553B Interface
- time gap for data/status readout and preparation for next pulse ~ 10 ms
- pulse current is integrated within external gate
- delayed gate duration is measured simultaneously
- mean pulse current is calculated by VME controller
- I/O control for BCT head amps on board
- I/O and analog signal via single cable

Bargraph display of mean currents in the main control room

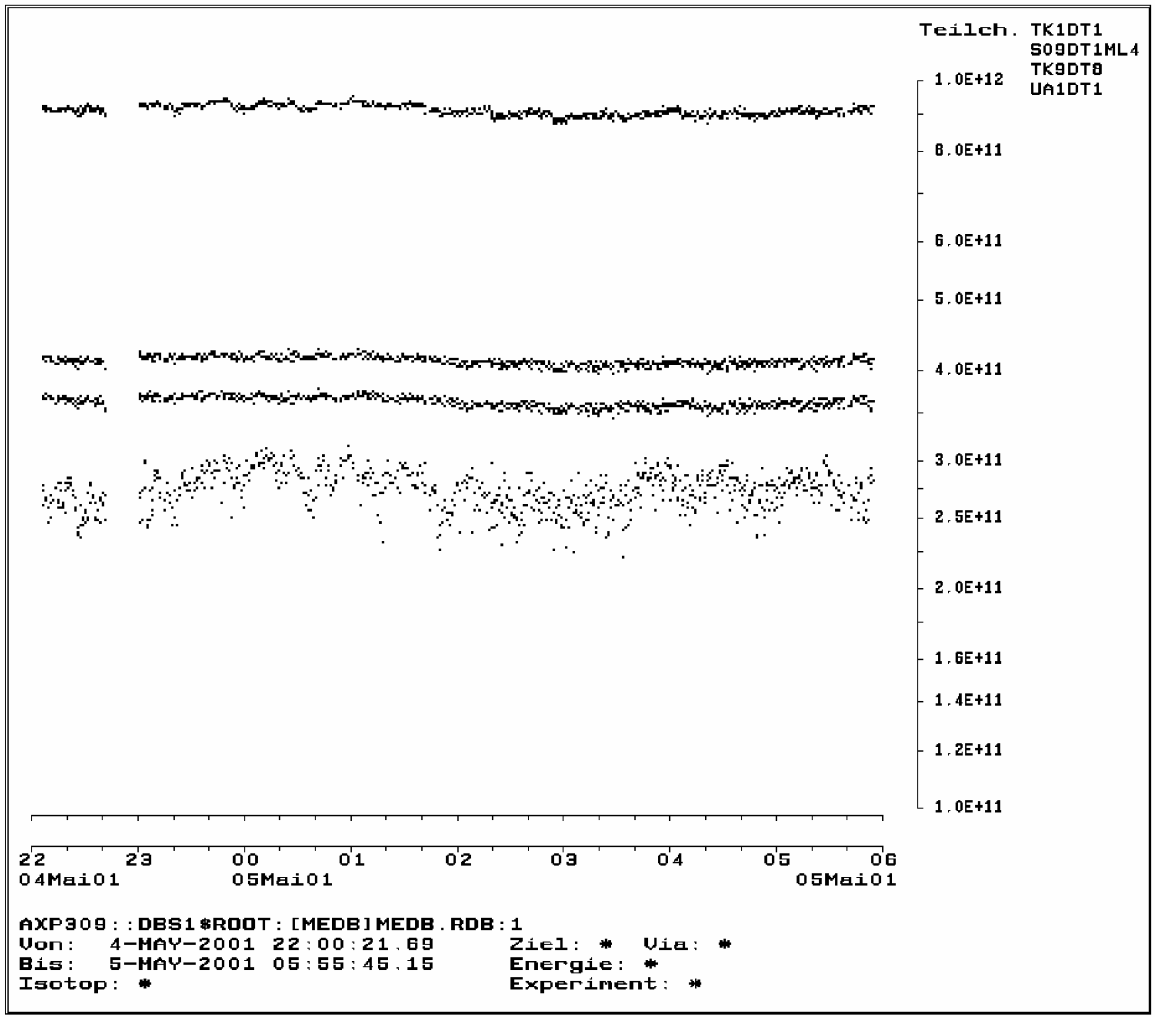


the operator's tool:

- consecutive BCT currents are displayed as bars; refresh rate is fast enough for manual beam optimization work
- BCTs are selected by clicking on little green dots
- automatic or manual gain switching is selectable

This program controls magnets, vacuum valves, beam diagnostic devices and displays their values

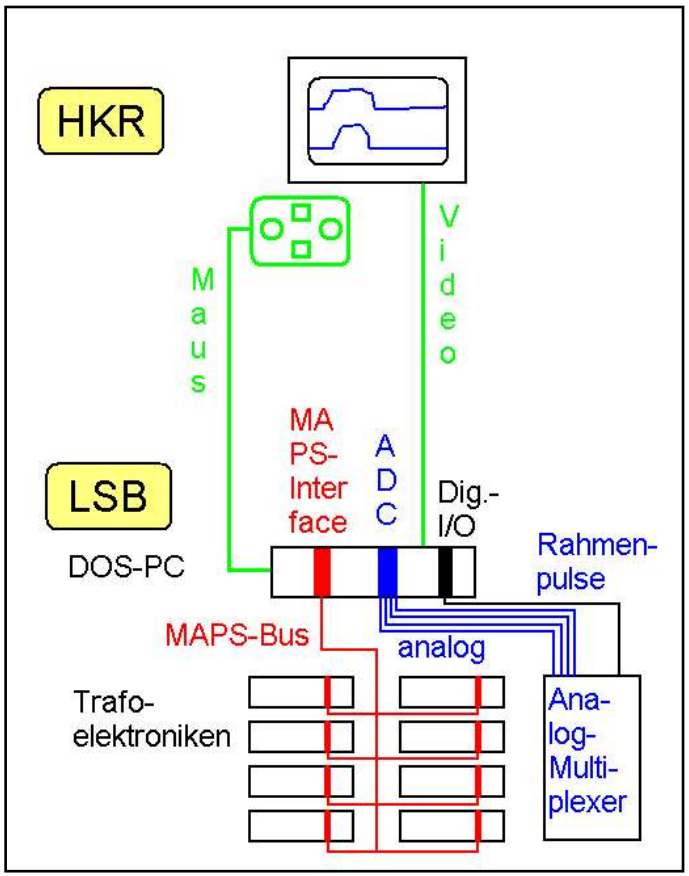
Plot of logged data from 4 BCTs along the UNILAC



- particles/pulse are calculated from measured currents and INIT data set
- mean currents of selectable BCTs can be logged on a long time scale, to observe beam intensity drifts and variation of particle transmission
- due to limitations of the GSI accelerator control system this is possible only on virtual accelerators allocated to SIS injection
- true single shot DAQ is provided, making averaging techniques obsolete; this had to be performed in the early years due to strong intensity flutuations of the ion sources

MAkro **P**ulse **S**elektor

- GSI control system unable to transmit/display BCT analog signals (makro pulse time structure)
- BUt: this task is important e. g. for ion source optimization by the operators
- A PC-based stand-alone system was established from 1994 to 1996

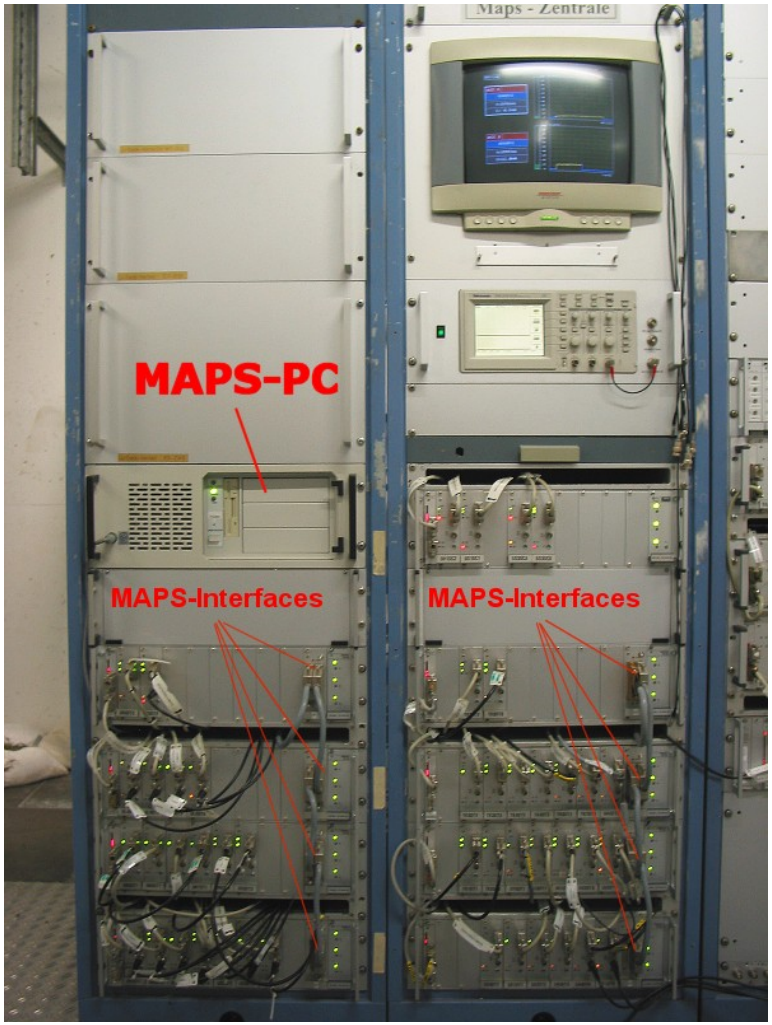


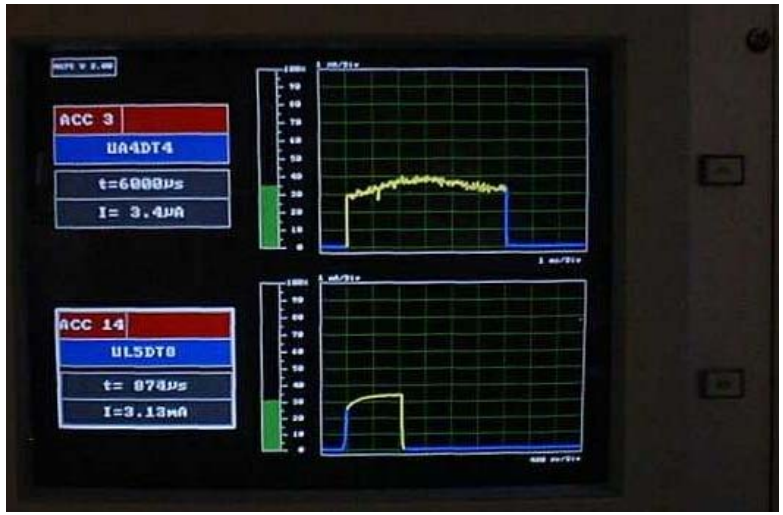
- x86-PC running special Borlan C application under MS-DOS
- 2 dual-ADC-boards, OEM dual 2-of-64 MUX for the analog signals and gate pulses
- OEM PC-Interface connected to MAPS-bus
- each crate equipped with OEM MAPS-Interface listening to the adress and data bus inside the crate
- designated VirtAcc and BCT set by operator via dialing knob (OEM by decomposing a serial PC mouse)

Principle:

If BCT data for preselected VrtAcc and BCT adress occur on device bus -> data are read, analog signal and gate are digitized and both is displayed on CRT

The old MAPS



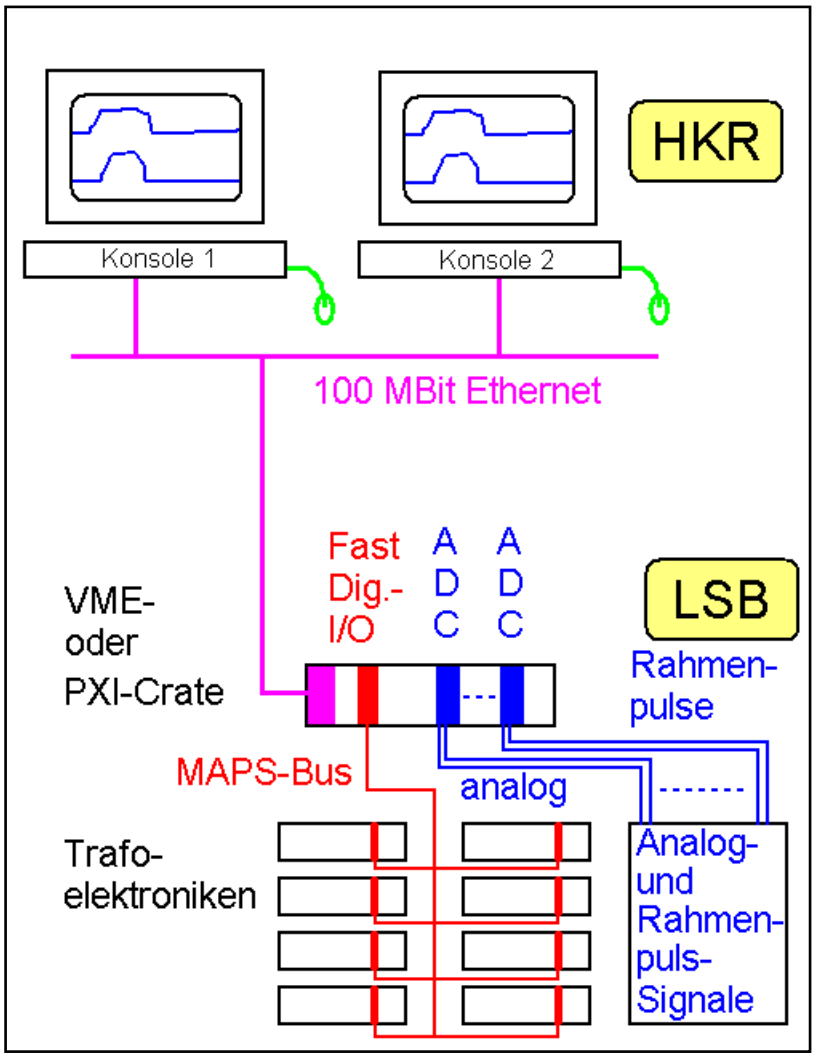


blue trace: BCT signal
yellow trace: gate pulse

- really useful tool, well accepted
- fast display refresh rate
- easy to operate by knobs and pushbuttons
- but: no logging, screendump etc. possible, limited address space e. g. number of selectable BCT

•-> upgrade required !

New MAPS – on the way ...



- several workstations possible
- sophisticated concept with operator and expert menu
- up to 10 BCTs on display
- data logging, trending & transmission for UNILAC VrtAccs
- less selfmade electronics, industrial hardware instead

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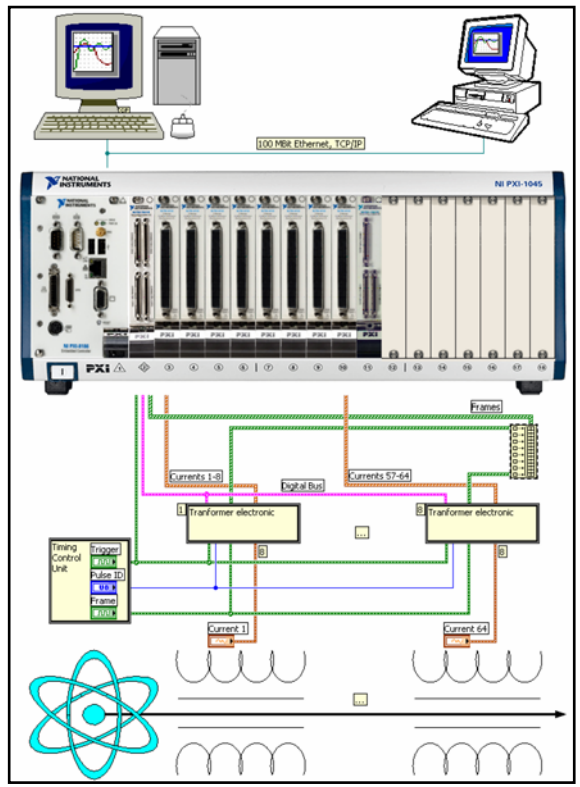
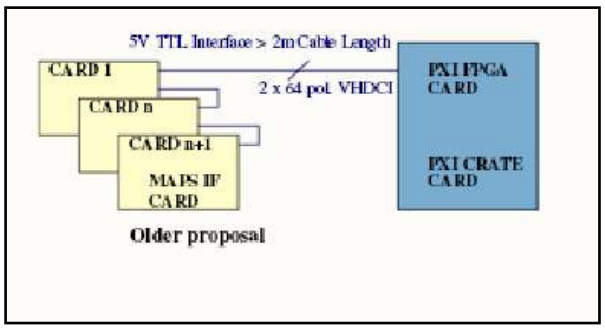


-> decision for PXI hardware from NI and LabView RT because of inhouse expertise and modularity

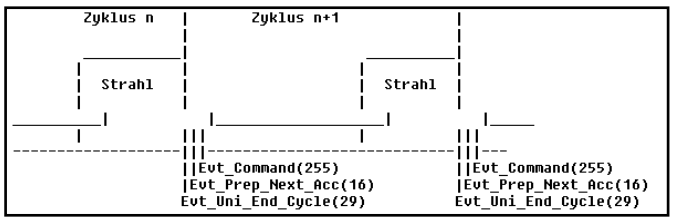
new MAPS-Bus

original idea:

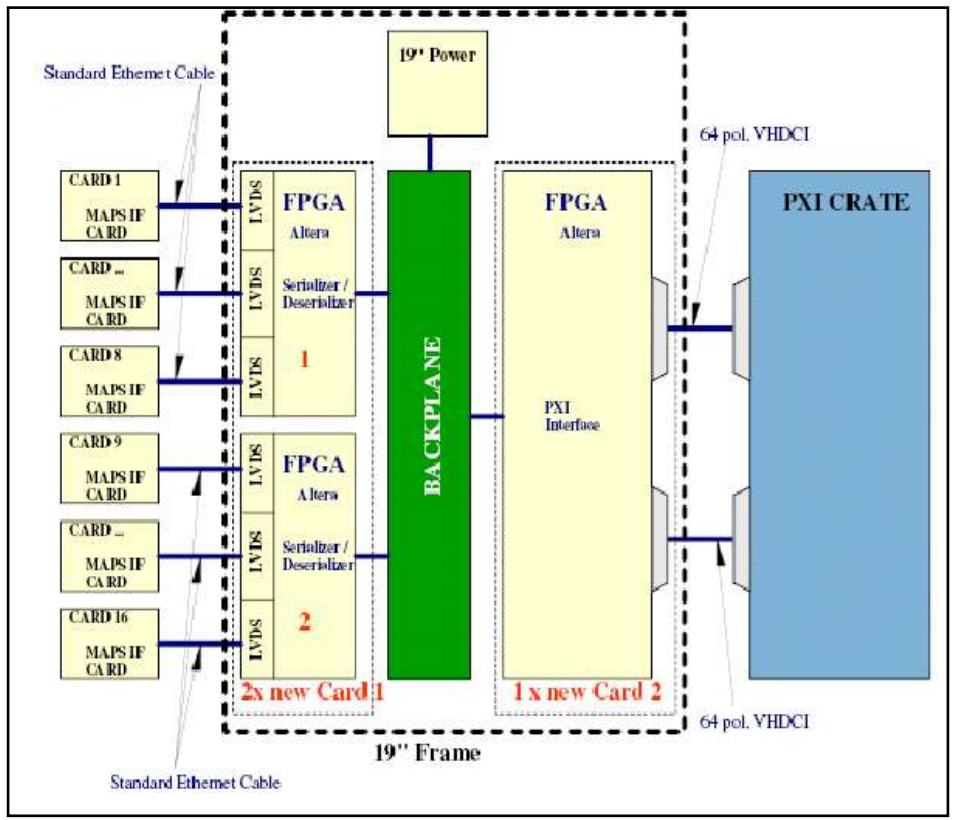


problems with hardware:
- data transfer speed
- cable length

-> cutout from UNILAC-Timing:



extended redsign: adapter card / data stream serializer



N_MAPS GUI (preliminary)